Dist: A

AD-A284 103

JMENTATION PAGE

Form Approved
OMB No. 0704-0188

2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	~~Interim~~ Annual 1JUL93 - 30JUN94

4. TITLE AND SUBTITLE
VISUO-OCULAR PERFORMANCE DURING VESTIBULAR STIMULATION

5. FUNDING NUMBERS
G F49620-93-1-0261
2313/CS
61102F

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8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 94 0510

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Office of Scientific Research/NL
United States Air Force
Lt BC Collins.

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.
A

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The objective of this study is to enhance knowledge regarding spatial orientation and disorientation in environments characterized by combined stress, namely simultaneous visual and vestibular stimulation. This study will test the hypothesis that target acquisition, ocular tracking, and visual search are degraded by vestibular stimulation using off-vertical axis rotation. Target acquisition stimuli will consist of a spot moving suddenly to a new location in a pseudo-random fashion; ocular tracking stimuli will consist of constant velocity target motion. Visual search will combine these stimuli. Eye movements will be recorded using the magnetic scleral search coil method. Analysis of the data will yield measures of saccadic latency and accuracy, and ocular pursuit gain. Calculated performance measures will be compared across visual and vestibular stimulus conditions with analysis of variance

The goal of the first year of research was to develop protocols and assess visual-vestibular interaction. As proposed for the first year, 15 normal subjects (8F, 7M) have been tested with the entire protocol of vestibular, visual, and visual-vestibular stimuli. With these first year studies completed, studies for the second year have begun.

14. SUBJECT TERMS	15. NUMBER OF PAGES -6-
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
N/A	N/A	N/A	N/A

VISUO-OCULAR PERFORMANCE DURING VESTIBULAR STIMULATION

ANNUAL TECHNICAL REPORT

A. Statement of Work

The objective of this study is to enhance knowledge regarding spatial orientation and disorientation in environments characterized by combined stress, namely simultaneous visual and vestibular stimulation. The specific aims of this study are 1) to define the ability of healthy young adults to integrate subject-fixed or earth-fixed visual stimulation with vestibular information when visual and vestibular sensations are in agreement and when they are in conflict; 2) test the hypothesis that target acquisition is degraded by vestibular stimulation; 3) test the hypothesis that ocular tracking is degraded by vestibular stimulation; and 4) test the hypothesis that visual search is degraded by vestibular stimulation. The proposed study will include both semicircular canal and otolith stimulation using off-vertical axis rotation (OVAR). The OVAR device consists of an 80 ft-lb turntable onto which is placed a subject fixture outfitted with a head holder. The turntable/fixture is placed on a hinged platform driven by a hydraulic linear actuator that smoothly tilts the axis of rotation to off-vertical at a selected rate of 0 to 1 deg/sec to a maximum tilt of 30 deg. Visual targets will be presented by a liquid crystal display (LCD) affixed to the rotating chair. The turntable and subject fixture unit are surrounded by a rigid cylindrical enclosure. During tilt, the turntable, subject fixture and enclosure all move together so that visual targets remain at a fixed distance from the subject regardless of the amount of tilt or the position of the subject rotationally. Stimuli for visual tasks will be single spot targets; target acquisition stimuli will consist of the spot moving suddenly to a new location in a pseudo-random fashion, varying

step timing and location; ocular tracking stimuli will consist of constant velocity target motion in horizontal, vertical and oblique directions with 180 degree reversals so that the target sweeps back and forth; visual search stimuli will be generated by interspersing constant velocity target motion segments with jumps to new locations and changes in the direction and velocity of the target. Eye movements will be recorded using the magnetic scleral search coil method. Analysis of vestibular-induced eye movements during rotational stimulation will be aimed at estimating gain and phase for sinusoidal rotations, vestibulo-ocular time constants for earth-vertical trapezoids and magnitude and phase of the modulation component and magnitude of the bias component for OVAR at constant velocity. Analysis of the data obtained during target acquisition, ocular tracking, and visual search will yield measures of saccadic latency and accuracy, and ocular pursuit gain. Calculated performance measures will be compared across visual and vestibular stimulus conditions with analysis of variance used to determine the relative effects of each stimulus.

B. Status of the Research Effort

The goal of the first year of research was to develop protocols and assess visual-vestibular interaction during semicircular canal, otolithic, and combined semicircular canal-otolithic stimuli. The rationale behind the first year's work was to perform those studies that were preliminary to the work to be performed in subsequent years regarding ocular motor performance during vestibular stimulation. The first year's work was aimed at investigating whether subjects could suppress their vestibular responses while looking at a small target that rotated with them, so-called vestibulo-ocular-fixation (VOR-fix). Also, subjects were rotated

with a lighted earth-fixed visual surround to assess their ability to augment their vestibular responses with vision (VVOR). For these studies, vestibular stimulation included semicircular canal, otolith, and combined semicircular canal-otolith stimulation. Other test modalities included vestibular stimulation in the dark and optokinetic stimulation while tilted-off vertical.

As proposed in the first year, 15 normal subjects (8F, 7M) have been tested with the entire protocol of vestibular, visual, and visual-vestibular stimuli. Each of these 15 subjects satisfied the inclusion criteria for this study based upon age and normality of routine vestibular tests.

Results to date suggest that during otolithic stimulation with off-vertical axis rotation (OVAR) that there are significant eye movements that are difficult for individuals to suppress. Moreover, during rotation in a lighted visual surround at constant velocity, a significant sinusoidal modulation of eye velocity was seen suggesting that visuo-ocular motor performance may be impaired during otolithic stimulation.

With these first year studies completed, studies for the second year have begun. Significant accomplishments have been made toward the testing of visuo-ocular performance during vestibular stimulation in that the subject population is now available; these subjects have undergone several test sessions, each to establish the normality of their vestibular function and baseline data regarding visual-vestibular interaction. Furthermore, technical details regarding the magnetic scleral search coil system have continued to be investigated including the development of algorithms for converting the voltages produced by the search coil system into eye position. The LCD screen that will be used to display the moving visual

targets has been purchased and a PC-based computer system dedicated for this aspect of the project has been purchased. Software scripts have been written to allow high level control of the moving visual targets. Interfacing between the PC-based visual target generating computer and the PDP11/73 computer that controls the chair movement and digitizes eye movement data is underway.

C. Publications

1. Furman JM, Carl J: Visual-vestibular interaction during off-vertical axis rotation. *Journal of Vestibular Research* (in-preparation).

D. List of professional personnel associated with the research effort

1. Joseph M. Furman, MD, PhD
2. James A. Carl, MD
3. Harry Plantinga, PhD

E. Interactions

i. Papers Presented:

AFOSR Spatial Orientation Program Review - "Visuo-Ocular Performance During Vestibular Stimulation", San Antonio, Texas, May 17-19, 1994

ii. Consultative Functions

None.

F. Inventions

None.

G. Other

Using additional funds supplied through AFOSR Grant Number F49620-0261 and Amendment #P00002, an audio-rendering system has been purchased. We are in the process of implementing this equipment and combining it with the OVAR facility.